and alumina and their crystallographic allies." But the explorer should clearly understand that, notwithstanding occasional accidents, the most trustworthy results in the search for minerals will, in the long run, be reached by that man who brings to bear upon his work the widest range of scientific knowledge.

The Process of Creation Discovered; or, the Self-evolution of the Earth and Universe by Natural Causes. By James Dunbar. Pp. viii + 290. (London: Watts and Co., 1898.)

To review this book would be to give prominence to a volume every page of which exemplifies the dangerous character of a little knowledge. We will merely remark that the author finds himself at variance with very many physical facts and theories, disbelieves the results of spectroscopic analysis applied to celestial bodies, and regards the solar photosphere as a deep ocean of water. According to his theory of inorganic evolution, "the only elements employed or necessary in the formation of the sun, solar system, and universe are those composing atmospheric air and water." Students of science may be left to form their own opinion upon a book containing an assertion of this kind.

Domestic Science Readers. Book vii. By Vincent T. Murché. Pp. 298. (London: Macmillan and Co., 1898.)

THE subject of domestic economy is taught in the various standards of our elementary schools; and this book is adapted to supply girls in the highest standards with the information which the Education Department expects them to possess. The laws of health, infant management, common ailments and their remedies, common accidents, infectious diseases, and management of the sick-room are the subjects dealt with in the six parts of the book, and they are treated in a very clear and instructive manner. Mr. Murché knows how to interest the young readers for whom he writes, and this little school book will doubtless be as successful as the others of which he is the author. Moreover, the pupils who read the book will receive a large amount of sensible advice which will give them a sound understanding of the laws of health, and thus be of service to them and to future generations.

A Course in Mechanical Drawing. By John S. Reid. Pp. 128. (New York: John Wiley and Sons. London: Chapman and Hall, 1898.)

TEACHERS of the elements of mechanical drawing to students in marine, electrical, railway, and mechanical engineering will find that this book contains a concise statement of the essential principles of the subject. In the five chapters, the author deals with drawing instruments, geometrical drawing, or the use of the instruments, conventional methods of drawing used by draughtsmen, lettering and figuring, and orthographic projection. The author is instructor in mechanical drawing and designing in Sibley College, Cornell University, and his experience has enabled him to produce a useful work.

Flower Favourites, their Legends, Symbolism and Significance. By Lizzie Deas. Pp. viii + 229. (London: George Allen, 1898.)

MANY pretty stories concerning common flowers have been collected from folk-lore and classic myths by the author, and are presented here in an attractive setting. The nursery traditions and love legends referring to flowers and flower-names are numerous and interesting enough, but very little attention is devoted to the subject of "plants and flowers in their widest relationships" referred to in the preface.

LETTER TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Röntgen Rays and Ordinary Light.

I QUITE agree with the physical principles in Lord Rayleigh's article on "Röntgen Rays and Ordinary Light" in NATURE of April 28, and think that the difference between us is one of terminology. I am accustomed to restrict the word wave to disturbances in which the harmonic character is well developed, and not to use it in physics in the sense in which it is used in the phrase "a wave of enthusiasm." It would never have occurred to me to speak of a disturbance localised in a thin shell as a wave of short wave-length. I should speak of it as a pulse, and though such pulses can of course be resolved by Fourier's theorem into trains of waves, yet it seems to me that when a simple pulse is so resolved (except for some special purpose), there is a loss of clearness both in expression and conception analogous to that which would occur if we regarded a straight line as an aggregate of harmonic curves.

The term pulse has the advantage that it suggests the fundamental property of the Röntgen rays, that their action on matter in their path is an *impulsive* action, *i.e.* that the time constant of the disturbance (the time taken by the pulse to pass over a point) is small compared with the time constant of the system in their path (the time of vibration of the molecules).

I am not aware that I have ever regarded these pulses as possessing any physical property which would be inconsistent with the physical properties of the constituents into which they can be resolved by Fourier's theorem. Personally I should expect that if a train of waves of wave-length λ were refracted, a pulse of thickness λ would be refracted too, and if the thickness of these pulses were of the order of the wave-length of ordinary light, that the Röntgen rays would be like ordinary light.

I believe the Röntgen rays to be pulses rather than waves of small wave-length, not because I think the properties of the latter would be different from those of Röntgen rays as far as we know them, but because electromagnetic theory shows that pulses, and not short waves, are produced by the impact of kathode rays.

J. J. THOMSON.

Cambridge, April 30.

SLEEP, AND THE THEORIES OF ITS CAUSE.

THE theory of the origin of sleep which has gained the widest credence is the one that attributes it to anæmia of the brain. It has been shown by Mosso, and many others, that in men with defects of the cranial wall the volume of the brain decreases during sleep. At the same time, the volume of any limb increases as the peripheral parts of the body become turgid with blood. In dogs, the brain has been exposed, and the cortex of that organ has been observed to become anæmic during sleep. It is a matter of ordinary observation that in infants, during sleep, the volume of the brain becomes less, since the fontanelle is found to sink in. It has been supposed, but without sufficient evidence to justify the supposition, that this anæmia of the brain is the cause and not the sequence of sleep. The idea behind this supposition has been that, as the day draws to an end, the circulatory mechanism becomes fatigued, the vasomotor centre exhausted, the tone of the blood vessels deficient, and the energy of the heart diminished, and thus is the circulation to the cerebral arteries lessened. By means of a simple and accurate instrument (the Hill-Barnard sphygmometer), with which the pressure in the arteries of man can be easily reckoned, it has been recently determined that the arterial pressure falls just as greatly during bodily rest as during sleep. The ordinary pressure of the blood in the arteries of young and healthy men averages 110–120 mm. of mercury. In sleep, the pressure may sink to 95–100 mm.; but if the pressure be taken of the same subject lying in bed, and quietly engaged on mental work, it will be found to be no higher. By mental strain or muscular effort, the pressure is, however, immediately raised, and may then reach 130–140 mm. of mercury. It can be seen from considering these facts that the fall of pressure is concomitant with rest, rather than with sleep. As, moreover, it has been determined on strong evidence that the cerebral vessels are not supplied with vasomotor nerves, and that the cerebral circulation passively follows every change in the arterial pressure, it becomes evident that sleep cannot be occasioned by any active change in the cerebral vessels. This conclusion is borne out by the fact that to produce in the dog a condition of coma like to sleep, it is necessary to reduce, by a very great amount, the cerebral circulation. Thus, both carotids and both vertebral arteries can be frequently tied at one and the same time without either producing coma or any very marked symptoms. The circulation is, in such a case, maintained through other channels, such as branches from the superior intercostal arteries which enter the anterior spinal artery. While total anæmia of the brain instantaneously abolishes consciousness, partial anæmia is found to raise the excitability of the cortex cerebri By estimation of the exchange of gases in the blood which enters and leaves the brain, it has been shown that the consumption of oxygen and the production of carbonic acid in that organ is not large. Further, it may be noted that the condition of anæsthesia is not in all cases associated with cerebral anæmia. Thus, while during chloroform anæsthesia the arterial pressure markedly falls. Such is not the case during anæsthesia produced by ether or a mixture of nitrous oxide and oxygen.

The arterial pressure of man is not lowered by the ordinary fatigue of daily life. It is only in extreme states of exhaustion that the pressure may be found decreased when the subject is in the standing position. The fall of pressure which does occur during rest or sleep is mainly occasioned by the diminished rate of the heart. The increase in the volume of the limbs is to be ascribed to the cessation of muscular movement, and to the diminution in the amplitude of respiration. The duty of the heart is to deliver the blood to the capilliaries. From the veins the blood is, for the most part, returned to the heart by the compressive action of the muscles, the constant change of posture and by the respiration acting both as a force and suction pump. All of these factors are at their maximum during bodily activity, and at their minimum during rest. On exciting a sleeper by calling his name, or in any way disturbing him, the limbs, it has been recorded, decrease in volume while the brain expands. This is so because the respiration changes in depth, the heart quickens, the muscles alter in tone, as the subject stirs in his sleep in reflex response to external stimuli. Considering all these facts, we must regard the fall of arterial pressure, the depression of the fontanelle, and the turgescence of the vessels of the limbs as phenomena concomitant with bodily rest and warmth, and we have no more right to assign the causation of sleep to cerebral anæmia than to any other alteration in the functions of the body, such as occur during sleep.

We may well here summarise these other changes in function.

(1) The respiratory movement becomes shallow and thoracic in type.

(2) The volume of the air inspired per minute is lessened by one-half to two-thirds.

(3) The output of carbonic acid is diminished by the same amount.

(4) The bodily temperature falls.

(5) The acidity of the cortex of the brain disappears.

(6) Reflex action persists; the knee jerk is diminished, pointing to relaxation in tone of the muscles; consciousness is suspended.

Analysing more closely the conditions of the central nervous system, it becomes evident that, in sleep, consciousness alone is in abeyance. The nerves and the special senses continue to transmit impulses, and to produce reflex movements. If a blanket, sufficiently heavy to impede respiration, be placed upon the face of a sleeping person, we know that it will be immediately pushed away. More than this, complicated movements can be carried out: the postillion can sleep on horseback; the punkah-wallah may work his punkah, and at the same time enjoy a slumber; a weary mother may sleep, and yet automatically rock her infant's cradle. Turning to the histories of sleep-walkers, we find it recorded that, during sleep, they perform such feats as climbing slanting roofs, or walking across dangerous narrow ledges and bridges. The writer knew of the case of a lad, who, when locked into his room at night to prevent his wandering in his sleep, climbed a partition eight to ten feet in height which separated his sleeping compartment from the next, and this without waking.

The brain can carry out not only such complicated acts as these, but it has been found to maintain during sleep its normal inhibitory control over the lower reflex centres in the spinal cord.

Thus, in sleeping dogs, after the spinal cord has been divided in the dorsal region, reflexes can be more easily evoked from the lumbar than from the cervical cord, because the former is freed from the inhibitory control of the brain.

The strength of stimulus necessary to pass the threshold of consciousness, and to produce an awakening, has been measured in various ways. It has been determined that it takes a louder and louder sound, or a stronger and stronger electric shock to arouse a sleeper during the first two or three hours of slumber; after that period, the sleep becomes lighter, and the required stimulus need be much less.

The alternative theories, which have been suggested to account for the onset of sleep, may be classed as chemical and histological.

In relation to the first, it has been suggested that if consciousness be regarded as dependent upon a certain rate of atomic vibration, it is possible that this rate depends on a store of intramolecular oxygen, which, owing to fatigue, may become exhausted; or it may be supposed that alkaloidal substances may collect as fatigue products within the brain, and choke the activity of that organ. Against this theory may be submitted the facts that monotony of stimulus will produce sleep in an unfatigued person, that over-fatigue, either mental or bodily, will hinder the onset of sleep, that the cessation of external stimuli by itself produces sleep. As an example of this last, may be quoted the case recorded by Strumpel of a patient who was completely anæsthetic save for one eye and one ear, and who fell asleep when these were closed. Moreover, many men possess the power, by an effort of will, of withdrawing from objective or subjective stimuli, and of thus inducing sleep.

The histological theories of sleep are founded on recent extraordinary advances in the knowledge of the minute anatomy of the central nervous system, a knowledge founded on the Golgi and methylene-blue methods of staining. It is held possible that the dendrites or branching processes of nerve cells are contractile, and that they, by pulling themselves apart, break the association pathways which are formed by the interlacing or synapses of the dendrites in the brain. Ramon y Cajal, on the other hand, believes that the neuroglia cells are contractile, and may expand so as to interpose their branches as insulating material between the synapses formed by the dendrites of the nerve cells. The difficulty of accepting these theories is that nobody can locate consciousness to any particular group of nerve-cells. Moreover, the anatomical evidence of such changes taking place is at present of the flimsiest character.

If these theories be true, what, it may be asked, is the agency that causes the dendrites to contract or the neuroglia cells to expand? Is there really a soul sitting aloof in the pineal gland, as Descartes held? When a man like Lord Brougham can at any moment shut himself away from the outer world and fall asleep, does his soul break the dendritic contacts between cell and cell; and when he awakes, does it make contacts and switch the impulses evoked by sense stimuli on to one or other tract of the axons, or axis cylinder processes, which form the association pathways? Such an hypothesis is no explanation: it simply puts back the whole question a step further, and leaves it wrapped in mystery. It cannot be fatigue that produces the hypothetical interruptions of the dendritic synapses and then induces sleep, for sleep can follow after fatigue of a very limited kind. A man may sleep equally well after a day spent in scientific research, as after one spent in mountain-climbing, or after another passed in idling by the seashore. He may spend a whole day engaged in mathematical calculation, or in painting a landscape. He fatigues—if we admit the localisation of function to definite parts of the brain—but one set of association tracts, but one group of cells, and yet, when he falls asleep, consciousness is not partially, but totally suspended.

We must admit that the withdrawal of stimuli, or their monotonous repetition, are factors which do undoubtedly stand out as primary causes of sleep. We may suppose, if we like, that consciousness depends upon a certain rate of vibration which takes place in the brain structure. This vibration is maintained by the stimuli of the present, which awaken memories of former stimuli, and are themselves at the same time modified by these. By each impulse streaming into the brain from the sense organs, we can imagine the structure of the cerebral cortex to be more or less permanently altered. The impulses of the present, as they sweep through the association pathways, arouse memories of the past; but in what way this is brought about is outside the range of explanation. Perhaps an impulse vibrating at a certain rate may arouse cells or fibrils tuned by past stimuli to respond to this particular rate of vibration. Thus may be evoked a chain of memories, while by an impulse of a different rate, quite another set of memories may be started. Tracts of association are probably formed in definite lines through the nervous system, as during the life of a child repeated waves of sense-impulses beat against and overcome resistances, and make smooth pathways here and there through the brain structure. Thus may be produced growth of axons in certain directions, and synapses of this cell with that. If the same stimulus be often repeated, the synapses between groups of cells may become permanent. A memory, a definite line of action which is manifested by a certain muscular response, may thus become structurally fixed. If the stimulus be not repeated, the synapses may be but temporary, and the memory fade as the group of cells is occupied by a new memory of some more potent sense stimulus. Many association tracts and synapses are laid down in the central nervous system when the child is born. These are the fruits of inheritance, and by their means, we may suppose, instinctive reflex actions are carried out.

So long as the present stimuli are controlled by past memories and are active in recalling them, so long does consciousness exist, and the higher will be the consciousness the greater the number and the more intense the character of the memories aroused. We may suppose that when all external stimuli are withdrawn, or the brain soothed by monotony of gentle repetition, and when the body is placed at rest, and the viscera are normal and give rise to no disturbing sensations, consciousness is then suspended, and natural sleep ensues. Either local fatigue of the muscles, or of the heart, or ennui, or exhaustion of some brain centre usually leads us to seek those conditions in which sleep comes. The whole organism may sleep for the sake of the part. To avoid sleeplessness, we seek monotony of stimulus either objective or subjective. In the latter case, we dwell on some monotonous memory picture, such as sheep passing one by one through a gap in the hedge. To obtain our object, we dismiss painful or exciting thoughts, keep the viscera in health, so that they may not force themselves upon our attention, and render the sense-organs quiet by seeking darkness, silence and warmth. L. H.

A PROPOSED REVOLUTION IN NAUTICAL ASTRONOMY.

DURING the last two years a movement has been set on foot, which seems likely to be attended by somewhat important results in the simplification of the formulæ of astronomical navigation for every-day use. Any one who has looked even cursorily into a text-book of navigation of the Raper type, can hardly fail to have been impressed by the multiplicity and variety of the precepts, and can easily understand how complicated the various rules must appear to the unlearned men, upon whom, for the most part, the daily routine of practical navigation at sea must devolve.

And the difficulty of comprehending and putting into practice the various rules, is undoubtedly increased by the fact that at one time or another all the trigonometrical functions of an angle are brought into play. Sines, cosines, tangents, cotangents, secants and cosecants, versed sines and half-versed sines, all make their appearance, adding to the bewilderment of the unskilled computer, and introducing the liability to take a required function from a wrong column as a very frequent source of error.

Nautical astronomy, for the most part, may be regarded as simply a practical application of the formulæ employed in the solution of spherical triangles, so that the object to be attained by those who would simplify the various problems, is to devise a system of formulæ in logarithmic shape, which, without materially adding to the amount of arithmetic employed, should introduce but one function of an angle throughout, such as the sine, the cosine, or the tangent. In the verbal precepts, into which, for the benefit of those possessing no knowledge of mathematics, the formulæ have to be translated, the simple word "logarithm" would then take the place of "log sine," "log cosine," &c., and a single table of a few thousand logarithms would do the work formerly effected by the aid of a large collection of different tables.

To M. E. Guyou, an officer of the French navy, belongs the credit of having first devised such a system. As far back as the year 1885 he published in a small pamphlet entitled "Tables de Poche," methods of finding hour angle and azimuth of a heavenly body by means of a single table of logarithms. During the next ten years he employed himself in further researches, and early in 1896 there appeared in connection with the "Annales Hydrographiques," published periodically by the Hydrographic Department of the French navy, a more exhaustive account of his methods, with a special arrangement of the required table, intended to enable his processes to be more easily and effectively carried out.[1]

The particular table employed by M. Guyou does not give logarithms for one of the ordinary functions of the

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[1] "Les problèmes de Navigation et la Carte Marine. Types de calcul et tables complètes." Par M. le capitaine de frégate E. Guyou, Membre de l'Académie des Sciences. (Paris: Imprimerie Nationale, 1895.)